



Carbon Nanotubes and Nanostructures–Multifunctional Material for Emission Electronics

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Vacuum electronic devices are still widely used in the industry especially in high power radars and high current electronics. Miniature vacuum electronic devices: BWT, $\Delta f = 1\div 4$ GHz, weight < 0.1 kg, BWT, $\Delta f = 36 - 300$ GHz, weight < 1 kg, are widely used in the ground, plane, spacecraft equipment, in the radiometers as heterodynes for various radars, in navigation devices etc.

Very important applications of vacuum electronic devices are X-Ray sources (in particular, in medicine), cathode – ray tubes, super high quality audio amplifiers, plasma TV displays, electron and scanning tunnel microscopy, etc.

The advantages of vacuum electronic devices are the following:

- high working temperatures (up to 800°K)
- high resistance to radiation (up to 10^{15} n/cm² and 10^{17} R/sec)
- high resistance with respect to electromagnetic fields, etc.

During latest two decades a new direction is being developed: vacuum microelectronics, which is based on the phenomenon of auto electron emission (or field electron emission), the emission of electrons from solid or liquid conductors or semiconductors to vacuum under the influence of strong electric field (usually $< 10^7$ v/cm).

This phenomenon was discovered by R. Wood in 1897 and studied later by R. Fowler and L. Nordheim in 1928-29 and by many others.

The main goals of vacuum microelectronics are the following:

- New electron emission guns for microwave devices
- New types of efficient displays (in particular for TV) with higher brightness and less energy consumption
- New types of X-Ray tubes operating at low voltage with high efficiency
- New types of special processors, working with super high speed under the conditions of high temperatures and high level of radiation and electromagnetic surroundings
- New efficient and harmless sources of light etc.

For all these devices and their applications one needs very efficient emitters of electrons into vacuum.

Electron field emission from carbon films containing nanotubes and nanostructures was first predicted and experimentally observed in 1993 in Saratov Branch of the Kotelnikov Institute of Radio-engineering and Electronics RAS and the results were presented at the 7th International Vacuum Microelectronics Conference IVMC'94 at Grenoble, France [1].

In the report we present a new electron field emission material which we developed in 1993 and studied during last 25 years. This material is carbon nanotubes and nanostructures.

1. Yu. V. Gulyaev, L. A. Chernozatonsky, Z. Ya. Kosakovskaya, N. I. Sinitsyn, G. V. Torgashov, Yu. F. Zakharchenko, Revus, “Le Vide, les Couches Minces”, Supplement au № 271-Mars-Avril 1994, submitted in 1993.